

Application No.: 09/764,001  
Filed: January 17, 2001  
Group Art Unit: 1754

REMARKS

1. This is in response to the Office Action mailed 7/30/02. Claims 1, 15-17, 19-25, and 28-29 are pending in this application.
2. Regarding the Restriction Requirement, Applicant elected Group I (claims 1 and 15-25) with traverse. Claims 26 and 27 have been cancelled without prejudice.
3. Applicant requests clarification regarding the Examiner's comment regarding the IDS. Applicant acknowledges receipt of one page of form PTO-892 (Paper No. 10) and 2 pages of initialed Form 1449. These forms are believed to include all the references cited in the specification. Applicant assumes that all of these references were considered by the Examiner.
4. A new copy of the Declaration is enclosed.
5. The Abstract has been amended as suggested by the Examiner.
6. Claims 24 and 25 have been amended as suggested by the Examiner. (The actual term in the specification at the cited place as amended is "reversing" Claus reaction.)

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WEINGARTEN, SCHURGIN,  
CAGNERIN & HAYES LLP  
TEL (617) 542-2250  
FAX (617) 491-0313

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7. New claims 28 and 29 have been added. Support for these claims can be found in current claims 1 and 17 and on page 7, line 32 of the application.

Claims 28 and 29 have been added in an effort to overcome the examiner's objection that there is an overlapping portion in the present invention compared to US '100 (office action page 10), wherein is specified that the surface area is at least 6 m<sup>2</sup>/g. The cited prior art does not suggest to use a catalyst having a surface area of more than 20 m<sup>2</sup>/g at all. In particular, it is not suggested to use a catalyst with a surface area chosen in the narrow range of 20-300 m<sup>2</sup>/g within the range specified in US '100.

8. Applicant requests reconsideration of the rejections under 35 USC 112, first paragraph.

a. Applicant has amended claim 1 to clarify that the claim applies to the reversing Clause reaction, which is the language used in the specification.

b. Claim 18 has been cancelled without prejudice.

9. Applicant has enclosed herein a terminal disclaimer in compliance with 37 CFR 1.321(c).

10. Applicant requests reconsideration of the rejections under

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35 USC 103.

a. The Examiner has relied, in part, on US 5,965,100 as a basis for the 35 USC 103 rejections. '100 has a filing date of 9/6/96 and is a continuation-in-part of US Application Ser. No. 08/428,031, which was filed 4/25/95. The priority date for the instant application is 3/4/96. Applicant requests clarification as to whether those portions of '100 relied upon by the Examiner were present in the parent case ('031) or whether they were added in the continuation-in-part application filed 9/6/96.

b. It is noted that the Examiner has relied, in part, on US 5,891,415 for the rejections under 35 USC 103. It is noted that this reference is not cited on either the PTO-1449 or -892 forms returned with the Office Action. Applicant requests that a supplemental PTO-892 be issued.

c. The present invention relates to a catalyst for the selective oxidation of sulfur-containing compounds to elemental sulfur. The catalyst comprises a catalytically active material and a support. The catalytically active material comprises a mixed oxide having atomically mixed iron ions and zinc ions in an oxidic lattice. The specific surface area of the catalyst is more than 20 m<sup>2</sup>/g, preferably 20-300 m<sup>2</sup>/g. The support and the catalytically active material exhibit substantially no reversing Claus activity under the reaction conditions of the selective oxidation.

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US 5,891,415 relates to a process for the oxidation of hydrogen sulfide at 300 °C or less, wherein use is made of a solid porous catalyst (preferably) consisting essentially of oxides of zinc and iron, the catalyst containing substantially no chromium. (see claim 1 & col 4, lines 35-38). The catalyst has a surface area of about 1.5 m<sup>2</sup>/g (col 4, lines 31-32).

Thus, the present invention is distinguished from the catalyst mentioned in US 5,891,415 in that the surface area is at least 4 times higher. Further, a catalytically active material comprising a mixed oxide having atomically mixed iron ions and zinc ions in an oxidic lattice is not disclosed. Furthermore, it is noted that although it is mentioned that a carrier can be used, US 5,891,415 clearly teaches away from using a catalyst on a support.

US 5,965,100 relates to a Claus process wherein use is made of a conventional Claus catalyst and of a special catalyst comprising a mixture of metal oxides or a mixed metal oxide, wherein the metal is defined as at least two of the transition metals occurring in the first transition group of the periodic table. The special catalyst is used at a temperature below 300 °C. As the only example of such a catalyst, a CuCrO<sub>2</sub> catalytic material on a carrier is disclosed. As carriers, activated alumina and silica are suggested, which are Claus active supports. The catalyst should have a surface area of at least 6

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WEINGARTEN, SCHURGIN,  
GAGNEBIN & HAYES LLP  
TEL (617) 542-2290  
FAX (617) 451-0313

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$\text{m}^2/\text{g}$ . However, no catalyst is actually shown herein with a surface area of more than  $20 \text{ m}^2/\text{g}$ .

First of all, even from the combination of both publications the skilled person would have no incentive to design a catalyst with a surface area of more than  $20 \text{ m}^2/\text{g}$ .

Further to the features that are known from the prior art cited, the skilled person would not be inclined to combine the teachings of both publications. After all, these publications point the skilled person to opposite directions in at least two aspects: Firstly, US '415 clearly teaches towards using a catalyst without a carrier whereas US '100 only refers to catalysts on a carrier; secondly US '415 stresses that the catalyst should be free of Cr, whereas US '100 in fact only shows a Cr containing catalyst. Thus there is no incentive for the skilled person to alter the catalyst in US '415 into a catalyst with a spinel-structure.

If the teachings of US '415 were to be combined with '100, the skilled person would at best consider trying to pick the preferred catalyst of US '415 and try to modify that based upon the teachings of US '100. Thus, the skilled person would at best arrive at a catalyst essentially consisting of the spinel-structure, i.e., without a support, which is still different from the present invention.

Furthermore, the advantage of using a spinel structure

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mentioned in US '100 is not relevant to a catalyst according to the invention. Spinels are said to oxidize COS and CS<sub>2</sub> to SO<sub>2</sub>. SO<sub>2</sub> would then be converted into elemental sulfur via the Claus reaction and thus increase the sulfur recovery (col 3, lines 9-11). Thus, this indicates that the special catalyst may show Claus activity, which is opposite to a required property of the catalyst according to the invention.

In addition, the citation (col 4, l 8-23 of US '100) that sulfates are formed that are unstable enough to react with H<sub>2</sub>S is no reason to use mixed oxides. It is known from V.d. Brink (thesis, Utrecht 1992, p 73 onwards; see enclosed) that a pure iron oxide catalyst on silica is deactivated by sulfation. Additionally, in the declaration by Geus (item 9 in the declaration filed 4/25/01) a iron oxide/iron sulfate active phase is mentioned. In fact, sulphate formation is not a problem at all for the process of US '415. The problem of sulphate formation is typical for deactivation of sulphated Claus catalysts, not to selective oxidation catalysts such as mentioned in US '415 or a catalyst according to the present invention.

Thus, it is not obvious at all to combine the teachings of US '100 and US '415, and even if these teachings were to be combined, there is no clear incentive to develop specifically a catalyst as defined in the present claims.

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Besides, it is not suggested in any way how such a catalyst could be prepared in US '100 or US '415. US '100 is completely silent about the preparation process (and thus is in fact non-enabling with respect to the preparation of a catalyst on a support wherein the catalytic material is a oxide of Zn and Fe) and US '415 only describes a method wherein a catalyst consisting of iron and zinc oxide is prepared (Example 1). This catalyst has a surface area well below 20 m<sup>2</sup>/g. As a result, based upon these publications, the skilled person would not know how to arrive at a catalyst according to the present invention.

Based upon these considerations, one can only conclude that the subject-matter of the present claims is non-obvious over the cited prior art.

With respect to claim 19, note that the cited prior art does not disclose a catalyst comprising a SiO<sub>2</sub> support that exhibits substantially no reversing Claus activity under the conditions as defined in the present application. As discussed above, US '415 definitely suggests not to use any support at all and US 100 only suggests Claus active support materials such as activated alumina  
silica.

With respect to claim 20, obviously US '415 teaches away from using a catalyst having a catalytically active material content of less than 50 % by weight because it teaches that it is preferred not to use a support. With respect to col 5, l. 54-

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56 of US '100, note that this only teaches that at least 20 wt.  
support, e.g. an  
% of CuCrO<sub>2</sub> can be present on a activated alumina or silicea,  
a support that does  
i.e., on supports that do not meet the criterion of "not having  
reversing Claus activity" as defined in the present claims. So  
both the catalytic material and the carrier are different from  
these components of a catalyst according to the present  
invention.

Method claims 21-23 are regarded by the Examiner as obvious  
over US '415 and US'100 and further in view of JP-56-10,338.

We agree with the Examiner that US '415 and US '100 do not  
show how to make a catalyst according to the present invention.

JP-56-10,338 relates to a process, wherein aluminum  
polychloride solution is treated at 100-150 °C, whereafter it is  
cooled. Then, a salt of one out of nine specified metals (M) is  
added, to obtain a coating solution. A carrier is immersed in  
the solution. The immersed carrier is then calcined to form a  
spinel type metal oxide MAl<sub>2</sub>O<sub>4</sub>.

It is not suggested that a metal oxide other than an oxide  
of aluminum and one other metal can be made by this method. In  
particular, it is not suggested that a mixed oxide of Fe and Zn  
can be made. Further, it is not suggested that a catalyst with a  
surface area of more than 20 m<sup>2</sup>/g can be made with this method.  
In addition, the skilled person would not find any suggestion in  
this publication that would motivate him to consider using this

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method in an effort to prepare a catalyst for use in a method according to US '415 or US '100. Please also note that the suggested purposes for the catalyst are different from the other citation. Thus this publication is totally irrelevant to the cited publications or the present invention.

With respect to claim 23, please note that the abstract of JP56-10338 is silent about the amount of chloride. As the other cited publications do not suggest the use of chloride at all, the subject-matter of the claim is not obvious over the cited art.

The Examiner is encouraged to telephone the undersigned attorney to discuss any matter that would expedite allowance of the present application.

Respectfully submitted,

JOHN WILHELM GEUS, ET AL.

By Holliday C. Heine  
Holliday C. Heine, Ph.D.  
Registration No. 34,346  
Attorney for Applicants

WEINGARTEN, SCHURGIN,  
GAGNEBIN & HAYES LLP  
Ten Post Office Square  
Boston, Massachusetts 02109

Telephone: (617) 542-2290  
Telecopier: (617) 451-0313

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WEINGARTEN, SCHURGIN,  
GAGNEBIN & HAYES LLP  
TEL (617) 542-2290  
FAX (617) 451-0313

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MARK-UP OF SPECIFICATION AND CLAIM AMENDMENTS

**Abstract:**

[The invention relates to a catalyst on support for the selective oxidation of sulfur-containing compounds to elemental sulfur, comprising at least one catalytically active material that is present on a support material, wherein the catalytically active material consists at least partly of a mixed oxide with an oxidic lattice, in which at least two metals in the form of ions are included.]

The invention provides a catalyst, a method for making the catalyst and a method for using the catalyst to promote the selective oxidation of hydrogen sulfide into elemental sulfur. The catalyst may be prepared by contacting a catalyst support, such as silica, with a mixed oxide having atomically mixed iron ions and zinc ions, to produce a support material impregnated with a mixed oxide having atomically mixed iron ions and zinc ions in an oxidic lattice. This impregnated catalyst support is then dried and calcined, preferably with chloride ions present, to produce a catalyst of an iron and zinc oxide mixture supported on silica. It has been found that when chloride is added to the impregnated catalyst support prior to calcination and drying, the sintering of the iron and zinc can be controlled more easily and the formation of iron and zinc oxide is promoted. It has also been found that the catalyst of the invention exhibits improved selectivity characteristics when compared to a catalyst prepared without the chloride.

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1. A catalyst on a support for the selective oxidation of sulfur-containing compounds to elemental sulfur, comprising at least one catalytically active material that is present on a support material, wherein the catalytically active material comprises a mixed oxide having atomically mixed iron ions and zinc ions in an oxidic lattice, which catalyst has a specific surface area of more than 20 m<sup>2</sup>/g and exhibits substantially no reversing Claus activity under the reaction conditions of said selective oxidation.

24. A method according to claim 21 or 22, wherein the chloride is [applied as] ammonium chloride.

25. A method according to claim 23, wherein the chloride is [applied as] ammonium chloride.